

In September, a bulldozer operator was digging a trench for a water line in a field near Abilene when his machine snagged an underground pipeline operated by ExxonMobil Pipeline Co. Butane, propane and ethane leaked from the broken pipeline, then exploded.

Abilene police Detective Jay Hatcher was killed by the explosion, which destroyed a home and melted the aluminum wheels of a sport-utility vehicle. The home's owner avoided death by jumping into her backyard lap pool.

On April 1, a Dome Pipeline Corp. pipe carrying gasoline ruptured and burst into flames a few miles west of Bottineau, N.D. The company estimated that more than 1.1 million gallons of gasoline burned before the pipeline could be shut down. It attributed the break to damage by an "outside force."

In this case, the outside force was frost, according to Bottineau County Sheriff Steven Watson. He said it appears the frost melted at uneven rates, twisting and breaking the pipeline.

And in some places, pipelines have even begun to endanger other pipelines.

An 8-inch Rio Grande Pipeline Co. pipe carrying a mix of butane and propane ruptured and caught fire near the West Texas town of Salt Flat in November 1999, according to reports filed with the Office of Pipeline Safety.

Wind pushed the flames over an above-ground Chevron crude oil pipeline nearby. When the Chevron line got hot, it began to leak. Then it, too, erupted in flames, losing about 430,000 gallons of crude oil. Explosions injured two truckers and barely missed two busloads of children.

A third pipeline, operated by Navajo Refining Co. of Artesia, N.M., was then overheated by the Chevron fire but, according to Navajo's report to the pipeline safety office, was not damaged. Chevron reported the cause of its spill as "outside force" -- another pipeline.

Undetected spills mar land, infiltrate water

Sometimes, the stresses endured by a pipeline lead to silent, chronic leaks that go undetected for months, even years.

Crews drilling a test hole to anchor a radio tower at the King Ranch in South Texas encountered underground water contaminated with oil. Nearly three years later, no one has been able to figure out which of three buried pipelines crossing the ranch is the source of the leak, said Doug Beveridge, vice president of minerals for the ranch.

"We think there is an enormous amount of this going on out there," Beveridge said. "It just doesn't come to the surface. We'll be finding underground plumes for years. If you have pipelines, you'll have leaks. Steel eventually corrodes."

Another silent leak, this one in a pipe owned by Atlanta-based Colonial Pipeline Co., was discovered in 1997. A partnership of 10 multinational oil companies, Colonial operates a 36-inch fuel artery from Pasadena to the suburbs of New York City, with branches along the way.

Enormous batches of fuel, each several miles long, rush through the pipeline from Houston's refineries to New York's consumers.

Colonial's engineers have realized in recent years that when the pipeline was built in the early 1960s some sections of pipe were improperly loaded onto rail cars to be delivered. As a result, the sections jostled and developed microscopic cracks, a phenomenon now known as "railroad fatigue."

Years of pressure changes as pumps are turned on and off have caused the cracks to grow. Occasionally the pipes rupture, and sometimes they are found to have been leaking for unknown periods of time.

In December 1997, Colonial maintenance workers were running a "smart pig" through a section of pipeline in Louisiana's St. Helena Parish. Smart pigs, which are inspection tools, grunt their way along the inside of pipelines, using magnetic fields to find cracks, leaks, corrosion and other anomalies that cause a pipe to fail.

The Colonial examination revealed a leak that turned out to amount to more than 420,000 gallons, said Colonial spokesman Sam Whitehead.

He acknowledged that without the smart-pig inspection, the company would not have known of the leak for months.

"To be honest, what we call slow leaks are a big concern of the industry," said Joy, the Association of Oil Pipe Lines counsel. "And that's one of the reasons smart-pig funding was developed in the first place."

Even if widely dispersed in a 157,000-mile liquid pipeline system, slow leaks can run up huge, undetected spill volumes. A hole one-fourth of an inch in diameter will leak 337,000 gallons of liquid from a pipeline in one year, according to calculations by pipeline expert Dagmar Etkin of Winchester, Mass.

Congress in 1992 directed the Office of Pipeline Safety to set up regulations no later than 1994 that would require pipeline operators to periodically "pig" segments of their lines in search of defects.

However, the OPS did not put the rule into effect until early this year, and the Bush administration delayed it for review until May. It applies only in highly populated areas, along commercially navigable waterways and in the most environmentally sensitive areas, which works out to a quarter of the hazardous liquid pipeline mileage. The agency says it plans to issue a rule for natural gas lines later. Meanwhile, agency officials acknowledged to the inspector general of the Department of Transportation last year that none of their safety investigators knows how to evaluate reports produced by the devices.

Responding to a written question, OPS officials said a contract to train an agency employee in how to read the "pig" reports has been signed.

"We consider it (the contract) a pilot test and are using it as a basis for more extensive training this fall (13 OPS employees)," the agency said.

In November at a National Transportation Safety Board hearing in Washington on pipeline safety, OPS officials estimated that about 37 percent of U.S. pipeline operators use smart pigs to inspect their pipes from the inside.

Crude measurements obscure scope of leaks

Despite a spotty record of finding and dealing with leaks, the pipeline industry has kept maintenance expenditures nearly flat during recent years.

Eighteen of the largest hazardous liquid pipeline operators in the country had income that totaled slightly more than \$2 billion in 1999, according to reports the companies are required to file annually with the Federal Energy Regulatory Commission. In 1995, the same companies had income totaling about \$1.7 billion.

In contrast to that \$300 million, or nearly 18 percent, increase in income, the companies reported that maintenance expenditures increased from \$352 million in 1995 to \$382 million in 1999, or about 8.5 percent.

Some of the large liquid pipeline operators actually decreased maintenance expenditures during that period. Exxon Pipeline Co. cut about \$8 million from its upkeep costs, down to \$48 million in 1999 from \$56 million in 1995. Santa Fe Pacific Pipeline, a subsidiary of the Kinder Morgan petroleum partnership in Houston, more than doubled its income, from about \$42 million in 1995 to \$114 million in 1999, but reduced pipeline maintenance from \$13 million to \$7 million. Others reporting reduced maintenance costs during the last half of the 1990s include Chevron Pipe Line Co., Lakehead Pipe Line Co. in Duluth, Minn., and Buckeye Pipe Line in Allentown, Pa.

Spokesmen for Exxon and Lakehead said heavy spending on new pipeline construction between 1995 and 1999 enabled the companies to reduce maintenance costs. A Buckeye Pipe Line spokesman said his company had become more efficient, primarily through automation. A Kinder Morgan spokesman did not respond to questions. Records show Chevron drastically reduced pipeline mileage between 1995 and 1999.

In the same Federal Energy Regulatory Commission reports, pipeline companies have consistently revealed a vague perception of how much material flows through their lines. In fact, the margin of error in measuring liquid pipeline flow is so great that many companies routinely report that they have delivered more oil product in a year than they received.

For example, more than 721 million barrels of petroleum products flowed through Colonial's system in 1999. However, in a report to the Federal Energy Regulatory Commission, which sets the fees pipeline operators may charge, Colonial reported that it received 718 million barrels from its shipper clients -- 3 million barrels, or 126 million gallons, less than it delivered.

Other pipeline companies show discrepancies in reporting quantities that pass through their pipelines as well.

Pipeline consultant Richard Kuprewicz of Redmond, Wash., said flow meters used for most pipelines are accurate to only about one-half of 1 percent. Pipeline operators and shippers work under the assumption that, year in and year out, the errors balance out, he said.

Colonial's Whitehead confirmed that the company's metering system is a gross balancing effort that "would not detect the smallest leaks."

Even a small hole in a pipeline can lead to catastrophe.

Three elderly people were killed on Jan. 14, 2000, when natural gas accumulated beneath a house in

Garland, near Dallas, and exploded. A report by the Texas Railroad Commission, which oversees some of the pipelines in the state, said the gas migrated from a crack in the area where two sections of 4-inch-wide plastic pipe were fused under a nearby alley.

A relative of the three victims had called the local utility, TXU Inc., four days earlier to report that the alarm on the home's carbon monoxide detector was going off, the Railroad Commission's report said. No telltale odor of natural gas was reported, and the TXU emergency operator advised the caller to contact a plumber, according to the commission. It is unknown whether a plumber was contacted, the agency's report said.

People working in a commercial building in San Juan, Puerto Rico, in 1996 complained repeatedly of nausea from the smell of propane, which continued to leak into the building from an Enron-owned gas line for a week. The gas eventually exploded, killing 33 people.

After an investigation, NTSB said inadequately trained gas company employees had searched for the leak but did not know how to find it. The safety board said the explosion might have been prevented had the OPS monitored Puerto Rico's pipeline safety program effectively.

Until an oil spill was discovered in the John Heinz National Wildlife Refuge near Philadelphia International Airport in February 2000, OPS inspectors had never visited the 50-year-old pipeline from which the oil was pouring.

After a hiker smelled oil and notified refuge officials, an investigation revealed that a short Sun Oil Co. pipeline had ruptured. Before the pumps could be turned off, 191,000 gallons of crude oil escaped into a rare urban wilderness.

When a reporter requested copies of previous OPS inspection reports on the pipeline, the request was denied on the grounds that the documents did not exist.

"I'm not sure we even knew that pipeline was there," said OPS official Linda Daugherty.

Haphazard reporting skews spill data

Pipeline industry representatives often point to the OPS database of oil spill reports from all over the country as an indication their industry is safe.

But there is widespread evidence that the database -- made up of information provided by pipeline companies -- is skewed because spills are underreported and cleanups exaggerated.

The OPS, unlike the Coast Guard, which closely monitors efforts to clean up spills from barges, tankers and other vessels, accepts the word of pipeline operators about the volume of spill that is recovered.

The OPS database on hazardous liquid spills even includes a handful of incidents in which pipeline operators are recorded as having recovered more than they spilled.

After the Interior Department and other agencies sued Chevron Products Co. for polluting Hawaii's Pearl Harbor and forcing closure of the USS Arizona National Memorial for several days in 1996, the company signed a consent decree, acknowledging the spill amounted to 39,000 gallons. But the OPS database records it at 25,000 gallons.

Although Colonial Pipeline officials estimated the 1997 leak in Louisiana at 420,000 gallons, the OPS database said it was a 38,000-gallon spill until a reporter asked the company about the discrepancy. The following day, the OPS changed the database.

National Park Service officials say a Colonial spill that sent fuel oil pouring into a cave system beneath Chickamauga battlefield near Chattanooga, Tenn., consisted of "more than 100,000 gallons." The OPS database says it was a 73,500-gallon spill.

Testifying in 1999 in a lawsuit against Koch Industries, Phillip Dubose of Lafayette, La., a former Koch division manager, told of literally covering up pipeline spills.

"If you had a spill or a leak, you wanted to get this thing taken care of with the least amount of dollars involved," Dubose testified during a deposition. "And so a lot of times, if it was out in a remote spot where nobody was around, they'd just take a shovel or something -- we're talking about a leak, a pipeline leak, now -- and just take a spade and just kind of spade it over and turn the soil over."

When asked under oath in a separate case if their company failed to report spills or intentionally understated spill volumes to government regulators, two Koch officials invoked the Fifth Amendment. One of the officials invoked the Fifth Amendment 17 times in response to questions about the company's practices.

The officials declined to answer because those matters were being investigated by a grand jury, a company spokesman said.

Neither Koch, which is the main supplier of gasoline to Central Texas, nor any company employee was charged with a crime concerning pipeline operations. Spokesman Marc Palazzo said: "We categorically deny these allegations. There's no evidence that supports any of these claims."

A May 1989 rupture in San Bernardino, Calif., of a 14-inch pipeline operated by Calnev offers a dramatic example of flaws in the spill database. When it broke, the pipeline spewed 300,000 gallons of flaming gasoline into nearby houses. Two people were killed and 31 injured. The flames destroyed 11 homes and 21 vehicles.

But even today, 12 years later, the OPS database indicates that Calnev places a value of "0" on the 11 destroyed homes and 21 cars and estimates the amount of gasoline that escaped from the ruptured, burning line at "0."

Although the record is obviously erroneous, the Office of Pipeline Safety cannot correct its database without written permission from Calnev. A spokesman for Calnev, now a subsidiary of Kinder Morgan Energy Partners in Houston, declined to answer questions about the report.

In response to the Calnev spill, the California Assembly ordered a study of pipeline spills in that state. The resulting audit of pipeline company records from 1981 through 1990 uncovered 317 spills involving estimated property damage of \$50,000 or more in each case. During that same period, OPS received only 31 reports of major pipeline spills in California.

Many of the unreported spills may have been from intrastate pipelines, which in California and a few other states are not included in requirements to report leaks and spills to the OPS. A review of state and federal records shows that many spills that meet the OPS reporting criteria never find their way

into its database.

Sunniland Pipeline, a now-idle crude oil pipeline that ran from Collier County on Florida's southern Gulf Coast to Miami's Port Everglades, notified the OPS in 1986 that a spill in its line had dumped 5,000 gallons of crude oil onto a sawgrass prairie in the Broward County portion of the Big Cypress National Preserve.

But files of the Florida Department of Environmental Protection describe nine other Sunniland spills in the Big Cypress preserve, none of which appears in the OPS database -- even though each accounted for 2,100 gallons or more, the minimum amount for which pipeline operators are required to report. The company is now defunct, and former officials could not be reached for comment.

No regulation at sources across rural America

Thousands of miles of pipelines are unregulated in America. These are the small gathering lines that carry crude oil and natural gas from wellheads in rural areas to collection points.

The amount of oil that drips into creeks, streams and underground water reservoirs from these lines may never be known because companies are not required to report such leaks to the OPS. But there's ample anecdotal evidence to suggest many of these lines are in bad shape.

The General Accounting Office, Congress' investigative arm, warned of increasing problems from rural gathering lines in a report 23 years ago. Although the report urged regulation, no action was taken.

In 1991, a corroded, 5-year-old Marathon Oil Co. natural gas gathering line near Carlsbad, N.M., leaked more than 2.3 million gallons of salt water and natural gas condensate liquids, enough to fill two Olympic-size swimming pools.

In reports filed with the New Mexico Oil Conservation Division and the federal Bureau of Land Management, which owns the land under which the pipeline broke, the company estimated that the line had been leaking five months when the leak was discovered.

Chris Shuey, environmental health specialist with the Southwest Research and Information Center, an environmental group, said the leak was discovered by accident.

"They didn't even know they were losing this stuff until the ground collapsed and they found it was saturated," he said.

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Exhibit D

Need: Excessive variations in tensile properties have been found in linepipe produced for several construction projects. High or low strengths, outside specification limits, present problems for the operator. The problem is likely to become worse due to fragmentation of the linepipe industry (often non-integrated steel and pipe mills) and due to the introduction of novel steelmaking and rolling methods.

Benefit: This study was conducted to determine tensile property variability and its origins in HFERW pipe produced from hot-rolled coils and DSAW pipe produced from plates. Data were collected for DSAW line pipe produced from plates made by flattening coiled skelp. Data have been collected from steelmakers and pipe mills in North America and other countries, including Australia, France, Mexico and Brasil. Results span the most advanced plate and pipe mills to older mills which do not always incorporate modern process control. Data for different steelmaking processes were collected and for different rolling philosophies. A limited amount of data from thin slab product are also presented.

Result: Results reveal significant variations in yield strength between individual slabs in a heat, as well as within the coils or plates produced from the slabs. This variability, which directly influences the variability in final pipe, is related to skill and know-how of the producers and to rolling schedules rather than to alloy design or age of production equipment.

<http://www.prci.com/publicationsIL51805e.htm>



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Stress Corrosion Cracking Study

FINAL DRAFT

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September 2004*

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TTO Number 8 Stress Corrosion Cracking Study

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List of Acronyms

AC	Alternating Current	FBE	Fusion Bonded Epoxy
AGA	American Gas Association	FFS	Fitness-for-Service
AOPL	Association of Oil Pipe Lines	GRI	Gas Research Institute
API	American Petroleum Institute	GTI	Gas Technology Institute
APIA	Australian Pipeline Industry Association	HAZ	Heat Affected Zone
AS	Australian Standard	HCA	High Consequence Area
ASME	American Society of Mechanical Engineers	HF-ERW	High-frequency Electric Resistance Welded
ASTM	American Society of Testing and Materials	ID	Inside Diameter
CEPA	Canadian Energy Pipeline Association	IEC	International Electrotechnical Commission
CFR	Code of Federal Regulations	ILI	In-Line Inspection
CIS	Close-Interval Survey	INGAA	Interstate Natural Gas Association of America
CP	Cathodic Protection	ISO	International Organization for Standardization
CSA	Canadian Standards Association	LF-ERW	Low-frequency Electric Resistance Welded
C-SCC	Circumferential Stress Corrosion Cracking	MAOP	Maximum Allowable Operating Pressure
CTOD	Crack Tip Opening Displacement	MAWP	Maximum Allowable Working Pressure
C-UT	Circumferential Ultrasonic Testing	MFL	Magnetic Flux Leakage
CVN	Charpy V-Notch	MIC	Microbiologically Influenced Corrosion
DC	Direct Current	MOP	Maximum Operating Pressure
DCVG	Direct-Current Voltage Gradient	MPI	Magnetic Particle Inspection
DSAW	Double Submerged Arc Weld	NACE	National Association of Corrosion Engineers
EAC	Environmentally Assisted Cracking	NAPSR	National Association of Pipeline Safety Representatives
ECA	Engineering Critical Assessment	NDT	Non-destructive Testing
EFW	Electric Flash Welded	NEB	National Energy Board (Canada)
EMAT	Electro Magnetic Acoustic Transducer	NPS	Nominal Pipe Size
ERW	Electric Resistance Welded	NSS	National Standards System
ET	Eddy Current Testing	OD	Outside Diameter
EW	Elastic Wave	OPS	United States Department of Transportation, Office of Pipeline Safety
FAD	Failure Assessment Diagram		
FATT	Fracture Appearance Transition Temperature		

PASC	Pacific Area Standards Congress
PRCI	Pipeline Research Council International
ROW	Right-of-Way
RSPA	Research and Special Programs Administration
SATT	Shear Appearance Transition Temperature
SAW	Submerged Arc Weld
SCADA	Supervisory Control and Data Acquisition
SCC	Stress Corrosion Cracking
SCCDA	Stress Corrosion Cracking Direct Assessment
SDO	Standards Development Organizations
SMYS	Specified Minimum Yield Strength
TCPL	TransCanada Pipelines Limited
TFI	Transverse Field Inspection
ULC	Underwriters' Laboratories of Canada
UT	Ultrasonic Testing